



## John T. Anderson Engineering Note

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**Project:** CFT Axial  
**Doc. No:** a980813a

**Subject:** Mapping of fibers on backplanes between left hand and right hand CFT boards

Each cassette in the CFT system has two boards, the *left-hand board* (LHB) and the *right-hand board* (RHB). Each board 'sees' one sector of fibers in the detector. In order to provide mapping of tracks across sector boundaries, the LHB and the RHB have to share data with each other, and also with their neighbors on either side. The terms 'previous' and 'next' are used to indicate these neighbor boards.

Within a left/right pair, the LHB is the 'previous' board to the RHB, which makes the RHB the 'next' board to the LHB. Within a backplane, the LHB of the adjacent left/right pair is the 'next' board to the RHB of the current left/right pair. This is shown graphically in Figure 1. The adjacent backplane may not be located in the physically adjacent crate; adjacency of backplanes is determined by the cables which interconnect them.

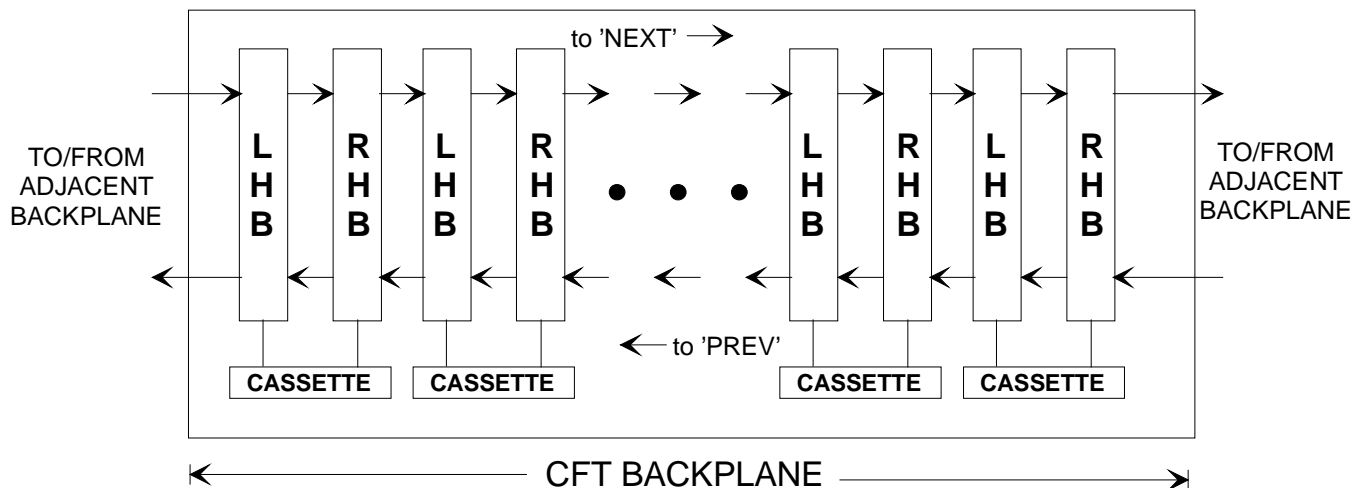


Figure 1

In the CFT documentation so far fibers are listed as being on 'inner' or 'outer' singlet layers, and each sector is numbered individually. This causes problems when thinking about the backplanes because it causes duplicate signal names within a LHB/RHB pair; for instance, both boards within a pair are connected to a Ai[0] fiber. To eliminate duplicitous signal names, an arbitrary fiber number is assigned for each fiber in a *pair* of sectors. This allows for signal names to be unique within a pair of boards. A picture of a sector pair with all fibers numbered is shown in Figure 2.

A heavy black line shows the breakout of connections from the sector pair into the board pair. Fibers to the left of the heavy black line are physically connected to the LHB, and fibers to the right are connected to the RHB. Each layer of the detector (A-H) is assigned numbers from 0 on up across the pair of sectors associated with a left/right pair of boards. This allows each cassette to be viewed independently of any other cassette and independent of detector angle. A left/right board pair receives all the fibers of a sector pair and transfers them to the logically previous and next boards in the detector. In order to save pins, a set of fibers are transferred each 53MHz clock tick within the 132 nsec cycle. Four clock cycles are used to transfer all fibers between all boards.

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## A Layer

There are 32 fibers presented to each board from the A layer. On the first clock tick all the discriminator outputs from the SIFTs on both boards are captured in Latch logic. On the four successive clock ticks the fibers are transmitted between boards. The clock used throughout is the 53 MHz main clock.

- The LHB of a pair receives fibers A0-A31. Of these, fibers A0-A3 are sent to the previous neighbor, fibers A28-A31 are sent to the RHB, and fibers A4-A27 are sent to both.
- The RHB of a pair receives fibers A32- A63. Fibers A32-A36 are sent to the LHB, fibers A60-A63 to the next neighbor and fibers A36-A59 are sent to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to previous neighbor	Latch data	A0	A1	A2	A3	1 out on LHB of pair 1 in on RHB in previous sector
LHB sends to RHB	Latch data	A28	A29	A30	A31	1 out on LHB of pair 1 in on RHB of pair
LHB sends to both previous neighbor and RHB	Latch data	A4,A5,A6, A7,A8,A9	A10,A11, A12,A13, A14,A15	A16,A17, A18,A19, A20,A21	A22,A23, A24,A25, A26,A27	6 out on LHB of pair 6 in on RHB in previous sector 6 in on RHB of pair
RHB sends to LHB	Latch data	A32	A33	A34	A35	1 out on RHB of pair 1 in on LHB of pair
RHB sends to next neighbor	Latch data	A60	A61	A62	A63	1 out on RHB of pair 1 in on LHB of next sector
RHB sends to both LHB and next neighbor	Latch data	A36,A37, A38,A39, A40,A41	A42,A43, A44,A45, A46,A47	A48,A49, A50,A51, A52,A53	A54,A55, A56,A57, A58,A59	6 out on RHB of pair 6 in on LHB of pair 6 in on LHB in next sector
						Total: Any LHB: 8 outputs, 14 inputs Any RHB: 8 outputs, 14 inputs

**Table 1**

Since the A layer is routed equally between boards, the number of I/O pins on the LHB and RHB are identical.

## B Layer

The B layer is a little more complicated than the A layer. Not only are there more fibers, but they aren't evenly split between the LHB and the RHB. A few extra fibers enter the RHB and have to be transferred from the RHB to the LHB. This is caused by fiber bundling and connector pinout limitations. These fibers can be viewed as part of the previous/next data passing but are counted out separately to insure correct pin counts.

- The LHB directly receives fibers B0-B31. Fibers B0-B11 are sent to the previous neighbor, fibers B28-B31 are sent to the RHB, and fibers B12-B27 are sent to both.
- The RHB receives fibers B32-B79. Fibers B32-B39 are sent to the LHB to make up for the bundling mismatches. In addition, fibers B40-B51 are sent to the LHB. Fibers B68-B79 are sent to the next neighbor and fibers B52-B67 to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to previous neighbor	Latch data	B0,B1,B2	B3,B4,B5	B6,B7,B8	B9,B10,B11	3 out on LHB of pair 3 in on RHB of previous sector
LHB sends to RHB	Latch data	B28	B29	B30	B31	1 out on LHB of pair 1 in on RHB of pair
LHB sends to both previous neighbor and RHB	Latch data	B12,B13, B14, B15	B16,B17, B18,B19	B20,B21 B22,B23	B24,B25, B26, B27	4 out on LHB of pair 4 in on RHB of previous sector 4 in on RHB of pair
Private RHB to LHB transfer	Latch data	B32, B33	B34,B35	B36,B37	B38,B39	2 out on RHB of pair 2 in on LHB of pair
RHB sends to LHB	Latch data	B40,B41,B42	B43,B44,B45	B46,B47, B48	B49,B50, B51	3 out on RHB of pair 3 in on LHB of pair
RHB sends to next neighbor	Latch data	B68,B69,B70	B71,B72,B73	B74,B75, B76	B77,B78, B79	3 out on RHB of pair 3 in on LHB of next sector
RHB sends to both LHB and next neighbor	Latch data	B52,B53, B54,B55	B56,B57, B58,B59	B60,B61, B62,B63	B64,B65, B66,B67	4 out on RHB of pair 4 in on LHB of pair 4 in on LHB of next sector
						Totals: LHB: 16 in, 8 out RHB: 12 in, 12 out

**Table 2**

Because of the mismatch in the number of fibers presented to the RHB and LHB, the number of inputs vs. outputs is different between the two board types. However, the total amount of I/O is the same for the two board types.

## C layer

The C layer, like the A layer, is evenly split between the two boards in a left/right pair. The LHB; the RHB sees. According to Manuel's notes, the two boards must pass data as follows:

- The LHB receives fibers C0-C47. It sends fibers C0-C19 to the previous neighbor, fibers C28-C47 to the RHB, and fibers C20-C27 to both.
- The RHB receives fibers C48-C95. It sends fibers C48-C67 to the LHB, fibers C76-C95 to the next neighbor and fibers C68-C75 to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to previous neighbor	Latch data	C0,C1,C2,C3,C4	C5,C6,C7,C8,C9	C10,C11,C12,C13,C14	C15,C16,C17,C18,C19	5 out on LHB of pair 5 in on RHB of previous sector
LHB sends to RHB	Latch data	C28,C29,C30,C31,C32	C33,C34,C35,C36,C37	C38,C39,C40,C41,C42	C43,C44,C45,C46,C47	5 out on LHB of pair 5 in on RHB of pair
LHB sends to both previous neighbor and RHB	Latch data	C20,C21	C22,C23	C24,C25	C26,C27	2 out on LHB of pair 2 in on RHB of pair 2 in on RHB of previous sector
RHB sends to LHB	Latch data	C48,C49,C50,C51,C52	C53,C54,C55,C56,C57	C58,C59,C60,C61,C62	C63,C64,C65,C66,C67	5 out on RHB of pair 5 in on LHB of pair
RHB sends to next neighbor	Latch data	C76,C77,C78,C79,C80	C81,C82,C83,C64,C85	C86,C87,C88,C89,C90	C91,C92,C93,C94,C95	5 out on RHB of pair 5 in on LHB of next sector
RHB sends to both LHB and next neighbor	Latch data	C68,C69	C70,C71	C72,C73	C74,C75	2 out on RHB of pair 2 in on LHB of pair 2 in on LHB of next sector
						Totals: LHB: 14 inputs, 12 outputs. RHB: 14 inputs, 12 outputs.

**Table 3**

Again, an evenly split sector pair results in matching I/O counts for the two board types.

## D layer

In the D layer, as in the B layer, eight fibers received by one board are passed to the other board in the left/right pair. The D layer passing requires that the LHB pass eight fibers (D56-D63) to the RHB. The fiber passing for previous/next architecture is as follows:

- The LHB receives fibers D00-D63 and sends fibers D00-D23 to the previous neighbor and fibers D32-D55 to the RHB. No fibers go to both.
- The RHB directly receives fibers D64-D111. Fibers D64-D79 are sent to the LHB, and fibers D88-D111 are sent to the next neighbor. No fibers go to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to previous neighbor	Latch data	D0,D1,D2, D3,D4,D5	D6,D7,D8, D9,D10,D11	D12,D13, D14,D15, D16,D17	D18,D19, D20,D21, D22,D23	6 out on LHB of pair 6 in on RHB of previous sector
LHB sends to RHB	Latch data	D32,D33, D34,D35, D36,D37	D38,D39, D40,D41, D42,D43	D44,D45, D46,D47, D48,D49	D50,D51, D52,D53, D54,D55	6 out on LHB of pair 6 in on RHB of pair
Private LHB to RHB transfer	Latch data	D56,D57	D58,D59	D60,D61	D62,D63	2 out on LHB of pair 2 in on RHB of pair
RHB sends to LHB	Latch data	D64,D65, D66,D67	D68,D69, D70,D71	D72,D73, D74,D75	D76, D77, D78, D79	4 out on RHB of pair 4 in on LHB of pair
RHB sends to next neighbor	Latch data	D88,D89,D90, D91,D92,D93	D94,D95, D96,D97, D98,D99	D100,D101, D102,D103, D104,D105	D106,D107, D108,D109, D110,D111	6 out on RHB of pair 6 in on LHB of next sector
						Totals: LHB: 14 outputs, 10 inputs RHB: 10 outputs, 14 inputs

**Table 4**

## E layer

The E layer is symmetric like the A and C layers. 128 fibers are split evenly between the two boards in a left/right pair.

- The LHB receives fibers E00-E63. Fibers E00-E31 are sent to the previous neighbor, E32-E63 to the RHB, and none to both.
- The RHB receives fibers E64-E127. Fibers E64-E95 are sent to the LHB, E96-E127 to the next neighbor, and none to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to previous neighbor	Latch data	E00,E01,E02, E03,E04,E05, E06,E07	E08,E09,E10, E11,E12,E13, E14,E15	E16,E17,E18, E19,E20,E21, E22,E23	E24,E25,E26, E27,E28,E29, E30,E31	8 out on LHB 8 in on RHB of previous sector
LHB sends to RHB	Latch data	E32,E33,E34, E35,E36,E37, E38,E39	E40,E41,E42, E43,E44,E45, E46,E47	E48,E49,E50, E51,E52,E53, E54,E55	E56,E57,E58, E59,E60,E61, E62,E63	8 out on LHB of pair 8 in on RHB of pair
RHB sends to LHB	Latch data	E64,E65,E66, E67,E68,E69, E70,E71	E72,E73,E74, E75,E76,E77, E78,E79	E80,E81,E82, E83,E84,E85, E86,E87	E88,E89,E90, E91,E92,E93, E94,E95	8 out on RHB of pair 8 in on LHB of pair
RHB sends to next neighbor	Latch data	E96,E97, E98,E99, E100,E101, E102, E103	E104,E105, E106,E107, E108,E109, E110,E111	E112,E113, E114,E115, E116,E117, E118,E119	E120,E121, E122,E123, E124,E125, E126,E127	8 out on RHB of pair 8 in on LHB of next sector
						Totals: 16 inputs & 16 outputs (both board types)

**Table 5**

## F layer

In the F layer, like the B layer, eight fibers are received by the RHB that really belong to the LHB.

- The LHB receives fibers F00-F63. Fibers F00-F23 are sent to the previous neighbor, fibers F48-F63 to the RHB and fibers F24-F47 to both.
- The RHB receives fibers F64-F143. Fibers F64-F71 are sent via private bus to the LHB to compensate for bundling mismatches. Fibers F72-F95 are also sent to the LHB. fibers F120-F143 are sent to the next neighbor and fibers F96-F119 are sent to both the LHB and the next neighbor.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to previous neighbor	Latch data	F00,F01,F02, F03,F04,F05	F06,F07,F08, F09,F10,F11	F12,F13,F14, F15,F16,F17	F18,F19,F20, F21,F22,F23	6 out on LHB of pair 6 in on RHB of previous sector
LHB sends to RHB	Latch data	F48,F49,F50, F51	F52,F53,F54, F55,	F56,F57,F58, F59	F60,F61,F62, F63	4 out on LHB of pair 4 in on RHB of pair
LHB sends to both previous neighbor and RHB	Latch data	F24,F25,F26, F27,F28,F29	F30,F31,F32, F33,F34,F35	F36,F37,F38, F39,F40,F41	F42,F43,F44, F45,F46,F47	6 out on LHB of pair 6 in on RHB of pair 6 in on RHB of previous sector
Private RHB to LHB transfer	Latch data	F64,F65	F66,F67	F68,F69	F70,F71	2 outputs on RHB 2 inputs on LHB
RHB sends to LHB	Latch data	F72,F73,F74, F75,F76,F77	F78,F79,F80, F81,F82,F83	F84,F85,F86, F87,F88,F89	F90,F91,F92, F93,F94,F95	6 out on RHB 6 in on LHB
RHB sends to next neighbor	Latch data	F120,F121, F122,F123, F124,F125	F126,F127, F128,F129, F130, F131	F132,F133, F134,F135, F136, F137	F138,F139, F140,F141, F142,F143	6 out on RHB 6 in on LHB of next sector
RHB sends to both LHB and next neighbor	Latch data	F96,F97, F98,F99, F100,F101	F102,F103, F104,F105, F106,F107	F108,F109, F110,F111, F112,F113	F114,F115, F116,F117, F118,F119	6 out on RHB 6 in on LHB 6 in on LHB of next sector
						Totals: LHB: 26 inputs, 16 outputs. RHB: 22 inputs, 20 outputs.

**Table 6**



## G layer

The G layer is again symmetric, with a total of 160 input fibers per board pair.

- The LHB receives fibers G00-G79. Fibers G00-G19 are sent to the previous neighbor, fibers G20-G59 to both the previous neighbor and the RHB, fibers G60-G79 to the RHB.
- The RHB receives fibers G80-G159. Fibers G80-G99 are sent to the LHB, fibers G100-G139 to both the LHB and the next neighbor, fibers G140-G159 to the next neighbor.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to previous neighbor	Latch data	G00,G01, G02,G03, G04	G05,G06, G07,G08, G09	G10,G11, G12,G13, G14	G15,G16, G17,G18, G19	5 out on LHB of pair 5 in on RHB of previous sector
LHB sends to RHB	Latch data	G60,G61, G62,G63, G64	G65,G66, G67,G68, G69	G70,G71, G72,G73, G74	G75,G76, G77,G78, G79	5 out on LHB of pair 5 in on RHB of pair
LHB sends to both previous neighbor and RHB	Latch data	G20,G21, G22,G23, G24,G25, G26,G27, G28,G29	G30,G31, G32,G33, G34,G35, G36,G37, G38,G39	G40,G41, G42,G43, G44,G45, G46,G47, G48,G49	G50,G51, G52,G53, G54,G55, G56,G57, G58,G59	10 out on LHB of pair 10 in on RHB of pair 10 in on RHB of previous sector
RHB sends to LHB	Latch data	G80,G81, G82,G83, G84	G85,G86, G87,G88, G89	G90,G91, G92,G93, G94	G95,G96, G97,G98, G99	5 out on RHB of pair 5 in on LHB of pair
RHB sends to next neighbor	Latch data	G140,G141, G142,G143, G144	G145,G146, G147,G148, G149	G150,G151, G152,G153, G154	G155,G156, G157,G158, G159	5 out on RHB of pair 5 in on LHB of next sector
RHB sends to both next neighbor and LHB		G100,G101, G102,G103, G104,G105, G106,G107, G108,G109	G110,G111, G112,G113, G114,G115, G116,G117, G118,G119	G120,G121, G122,G123, G124,G125, G126,G127, G128,G129	G130,G131, G132,G133, G134,G135, G136,G137, G138,G139	10 out on RHB of pair 10 in on LHB of pair 10 in on LHB of next sector
						Totals: 30 inputs & 20 outputs (both types)

**Table 7**

## H layer

The outermost, or H layer, is asymmetric and contains a total of 176 fibers. Eight fibers are received by the LHB and sent via private bus to the RHB.

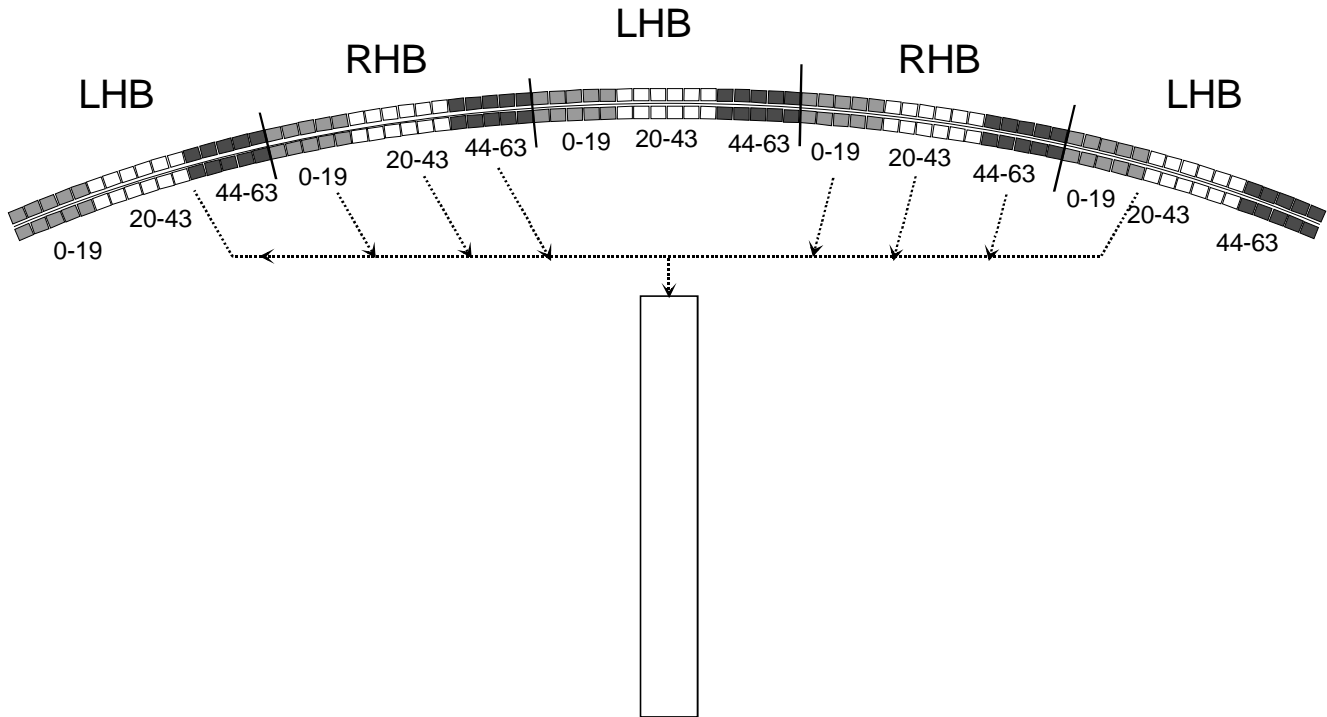
- The LHB receives fibers H00-H95. Fibers H00-H15 are sent to the previous neighbor. Fibers H16-H71 are sent to both the previous neighbor and to the RHB. Fibers H72-H95 are sent to the RHB.
- The RHB directly receives fibers H96-H176. Fibers H96-H103 are sent to the LHB. Fibers H104-H159 are sent to both the LHB and the next neighbor. Fibers H160-H179 are sent to the next neighbor.

Clock Tick	1	2	3	4	5	Pins required on a given board
Private bus, LHB to RHB	Latch data	H72,H73	H74,H75	H76,H77	H78,H79	2 out on LHB of pair 2 in on RHB of pair
LHB sends to previous neighbor	Latch data	H00,H01, H02,H03	H04,H05, H06,H07	H08,H09, H10,H11	H12,H13, H14,H15	4 out on LHB of pair 4 in on RHB of previous sector
LHB sends to RHB	Latch data	H80,H81, H82,H83	H84,H85, H86,H87	H88,H89, H90,H91	H92,H93, H94,H95	4 out on LHB of pair 4 in on RHB of pair
LHB sends to both previous neighbor and RHB	Latch data	H16,H17, H18,H19, H20,H21, H22,H23, H24,H25, H26,H27, H28,H29	H30,H31, H32,H33, H34,H35, H36,H37, H38,H39, H40,H41, H42,H43	H44,H45, H46,H47, H48,H49, H50,H51, H52,H53, H54,H55, H56,H57	H58,H59, H60,H61, H62,H63, H64,H65, H66,H67, H68,H69, H70,H71	14 out on LHB of pair 14 in on RHB of pair 14 in on RHB of previous sector
RHB sends to LHB	Latch data	H96,H97	H98, H99	H100,H101	H102,H103	2 out on RHB of pair 2 in on LHB of pair
RHB sends to next neighbor	Latch data	H160,H161, H162,H163	H164,H165, H166,H167	H168,H169, H170,H171	H172,H173, H174,H175	4 out on RHB of pair 4 in on LHB of next sector
RHB sends to both next neighbor and LHB	Latch data	H104,H105, H106,H107, H108,H109, H110,H111, H112,H113, H114,H115, H116,H117	H118,H119, H120,H121, H122,H123, H124,H125, H126,H127, H128,H129, H130,H131	H132,H133, H134,H135, H136,H137, H138,H139, H140,H141, H142,H143, H144, H145	H146,H147, H148,H149, H150,H151, H152,H153, H154,H155, H156,H157, H158,H159	14 out on RHB of pair 14 in on LHB of pair 14 in on LHB of next sector
						Totals:  LHB: 34 inputs, 24 outputs.  RHB: 38 inputs, 20 outputs.

**Table 8**

## Preshower signals

Each sector of the detector has 32 Preshower strips in addition to all the fibers. To further complicate the situation, each of the 32 Preshower strips seen by an LHB or RHB is sampled twice – against two different thresholds. Thus, 64 bits of preshower information is actually transmitted by each board. The preshower geometry is such that each CFT board sees, in addition to it's area, all the preshower information of both neighbor boards plus some data from the next board past the neighbor. This geometry is shown in Figure 3.



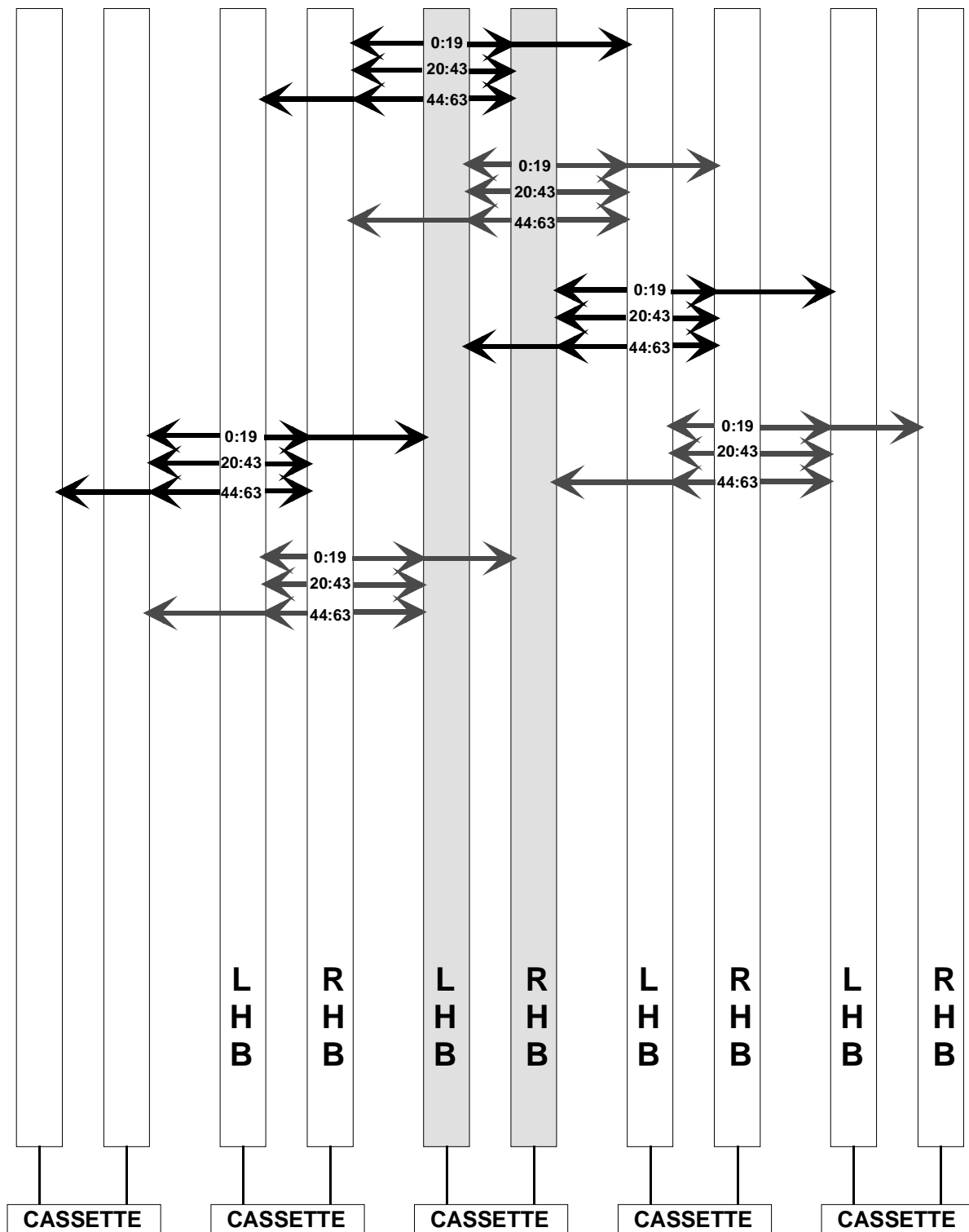
**Figure 3**

This interconnection scheme requires a large number of pins per board. Table 9 shows the pin requirements for the LHB and the RHB.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to RHB of pair, RHB in previous sector and the LHB previous to that RHB	Latch data	PS0,PS1, PS2,PS3, PS4	PS5,PS6, PS7,PS8, PS9	PS10,PS11, PS12,PS13, PS14	PS15,PS16, PS17,PS18, PS19	5 out on LHB of pair 5 in on RHB of pair 5 in on RHB of previous sector 5 in on LHB of previous sector
LHB sends to RHB in previous sector and RHB of pair	Latch data	PS20,PS21, PS22,PS23, PS24,PS25	PS26,PS27, PS28,PS29, PS30,PS31	PS32,PS33, PS34,PS35, PS36,PS37	PS38,PS39, PS40,PS41, PS42,PS43	6 out on LHB of pair 6 in on RHB of pair 6 in on RHB of previous sector
LHB sends to RHB of previous sector, RHB of pair and to LHB in next sector	Latch data	PS44,PS45, PS46,PS47, PS48	PS49,PS50, PS51,PS52, PS53	PS54,PS55, PS56,PS57, PS58	PS59,PS60, PS61,PS62, PS63	5 out on LHB of pair 5 in on RHB of previous sector 5 in on RHB of pair 5 in on LHB of next sector
RHB sends to LHB of pair, RHB in previous sector and the LHB in next sector	Latch data	PS0,PS1, PS2,PS3, PS4	PS5,PS6, PS7,PS8, PS9	PS10,PS11, PS12,PS13, PS14	PS15,PS16, PS17,PS18, PS19	5 out on RHB of pair 5 in on LHB of pair 5 in on RHB of previous sector 5 in on LHB of next sector
RHB sends to LHB in next sector and LHB of pair	Latch data	PS20,PS21, PS22,PS23, PS24,PS25	PS26,PS27, PS28,PS29, PS30,PS31	PS32,PS33, PS34,PS35, PS36,PS37	PS38,PS39, PS40,PS41, PS42,PS43	6 out on RHB of pair 6 in on LHB of pair 6 in on LHB of next sector
RHB sends to LHB of pair, LHB of next sector and RHB of next sector	Latch data	PS44,PS45, PS46,PS47, PS48	PS49,PS50, PS51,PS52, PS53	PS54,PS55, PS56,PS57, PS58	PS59,PS60, PS61,PS62, PS63	5 out on RHB of pair 5 in on LHB of pair 5 in on LHB of next sector 5 in on RHB of next sector
						Totals:  16 output and 42 input pins, both board types.

**Table 9**

A more ‘backplane’ view of the preshower data passing is given in Figure 4.



An LHB has 64 output signals and receives a total of 168 signals (16 & 42 pins)

An RHB has 64 output signals and receives a total of 168 signals (16 & 42 pins)

Figure 4

## ***Backplane Summation***

This last table summarizes how many inputs and outputs each type of board – LHB and RHB – requires.

	<b>LHB</b>		<b>RHB</b>	
Layer	Inputs	Outputs	Inputs	Outputs
A	14	8	14	8
B	16	8	12	12
C	14	12	14	12
D	10	14	14	10
E	16	16	16	16
F	26	16	22	20
G	30	20	30	20
H	34	24	38	20
PS	42	16	42	16
<b>TOTALS</b>	202	134	202	134
<b>GRAND TOTAL</b>	336		336	

**Table 10**